DATA TRANSMISSION SYSTEM, FRAME STRUCTURE, AND METHOD FOR RADIO TRANSMISSION OF DATA

Cross-Reference to Related Application:

5   This application is a continuation of copending International Application No. PCT/DE02/00450, filed January 30, 2002, which designated the United States and was not published in English.

Background of the Invention:

Field of the Invention:

10   The invention relates to a system for wireless transmission of data between a base station and at least two mobile stations, a frame structure, and a method for radio transmission of data.

Data transmission systems in which data is interchanged

15   without the use of wires over short distances of only a few meters between a base station and mobile stations are referred to as piconetworks. The frequencies available for data transmission in piconetworks are defined by the ISM frequency bands (Industrial, Scientific, and Medical). The ISM

20   frequency bands are reserved for use, based on radio and without licenses, at low transmission powers.

A data transmission from the base station to the mobile

stations is referred to as a downlink. The converse case, of

data transmission from the mobile stations to the base

station, is referred to as an uplink. Time slot methods are

5 normally used for data transmission. In time slot methods,

time slots with a specific time duration are assigned to the

downlinks and uplinks. The TDMA (time division multiple

access) method is frequently used as a multiple access method

for time slot methods, and the TDD (time division duplex)

10 method is used as a duplexing method in order to form a

bidirectional channel between the base station and the mobile

stations.

In previous data transmission systems based on a time slot

method, each data block which is intended to be transmitted

15 from the base station to a specific mobile station or from one

of the mobile stations to the base station is allocated one

time slot. A time slot method such as this is described, by

way of example, in the "Bluetooth Specification Version 1.0B",

in Chapter 2, "Physical Channel", (Internet Address

20 "www.bluetooth.com/developer/specification/Bluetooth_11_Specif

ications_Book.pdf" and in particular in Chapter 2.3 "Time

Slots" (pages 43, 44) there. When successive data burst are

transmitted from different stations, it will be possible for

the data blocks to overlap in time owing to the asynchronous

25 transmission cycles of the stations. In order to compensate

for such an overlap of the data burst originating from different stations, guard time intervals are planned in between the transmission of the individual data bursts. In the following text, the expression data burst means a sequence

5   of one or more data blocks transmitted without any interruption. No data transmission takes place during the guard time intervals.

The Standard defined by the Federal Communications Commission (FCC) for the use of the ISM frequency bands (Internet Address

10   www.fcc.gov/oet/info/rules/part15/) defines a frequency hopping method (Frequency Hopping Spread Spectrum) and stipulates how may frequency changes must take place within the specific time intervals. The rules relating to this can be found in Section 15.247 of the FCC rules, in particular in

15   Section 15.247 (1) (ii) there. In frequency hopping methods, the transmission frequency is changed once a specific number of data blocks have been transmitted. Every change in the transmission frequency results in the frequency synthesizer requiring time to stabilize the new transmission frequency.

20   The stabilization times must be taken into account in the length of the guard time intervals between the data blocks.

The transmission pauses which are forced to occur by the guard time intervals disadvantageously reduce the data transmission rate. Furthermore, the guard time intervals result in long

latency times.   The expression latency times in this context

means the times that pass from the start of transmission of a

data block to a specific station to the reception of the

response from this station.   These latency times are

5   particularly critical in systems with real-time requirements.

Summary of the Invention:

It is accordingly an object of the invention to provide a data

transmission system, a frame structure, and a method for radio

transmission of data that overcome the hereinafore-mentioned

10   disadvantages of the heretofore-known devices of this general

type and that allow a high data transmission rate, and in

which the latency times are reduced.

With the foregoing and other objects in view, there is

provided, in accordance with the invention, a data

15   transmission system.   The data transmission system includes a

base station and at least two mobile stations in a piconetwork

for interchanging data bursts successively by radio using a

time slot method.   A transmitter of the base station is

configured to transmit first data bursts to the mobile

20   stations.   At least some of the first data bursts contain at

least two data blocks intended for different ones of the

mobile stations.   The transmitter is configured to produce

identification information for the piconetwork only at a start

of a transmission of each of the first data bursts.   Each of

the mobile stations has a transmitter configured to transmit a group of second data bursts containing a data block intended for the base station. The transmitter is configured to produce identification information for the piconetwork at a

5   start of a transmission of the second data bursts. A device produces a guard time interval between the data bursts.

With the objects of the invention in view, there is also provided a frame structure for radio transmission of data bursts between a base station and at least two mobile stations

10   in a piconetwork. The frame structure includes first data bursts transmitted from the base station to the mobile stations, with at least some of the first data burst containing at least two data blocks. Each of the data blocks is intended for different mobile stations, and further

15   contains identification information for the piconetwork at a start of each of the first data bursts. Second data bursts are transmitted from a respective one of the mobile stations to the base station. Each of the second data bursts contain a data block intended for the base station and containing

20   identification information for the piconetwork at a start of each of the second data bursts. Guard time intervals bare provided between successive data bursts.

With the objects of the invention in view, there is also provided a method for radio transmission of data in a

piconetwork between a base station and at least two mobile

stations The first step of the method is transmitting a first

data burst from the base station to the mobile stations. The

first data burst contains at least two data blocks, each

5   intended for a different one of the mobile stations, and

including transmitting identification information for the

piconetwork only at a start of a transmission of the first

data burst. The next step is providing a guard type interval.

The next step is transmitting the second data bursts from one

10   of the mobile stations to the base station. Each of the

second data bursts contains a data block intended for the base

station. Each of the mobile stations transmits identification

information for the piconetwork at a start of a transmission

of the second data bursts.

15   A data transmission system according to the invention includes

a base station and at least two mobile stations, between which

data bursts are interchanged by radio, using a time slot

method. One major idea of the invention is for the data

transmission system to have a transmitter for transmission of

20   first data bursts from the base station to mobile stations,

with at least some of the first data bursts containing two or

more data blocks which are intended for different mobile

stations. Furthermore, the data transmission system includes

a transmitter for transmission of second data bursts from at

25   last one of the mobile stations to the base station. The

second data bursts contain data blocks that are intended for the base station. Guard time intervals, which are produced by suitable devices, are provided between successive date bursts.

The transmitters for transmission of the data bursts and
5   devices for production of the guard time intervals include, in particular, the transmitting and receiving devices in the base and mobile stations.

One advantage of the data transmission system according to the invention is that two or more data blocks that are intended
10   for different mobile stations can be transmitted using a single, first data burst. Thus, there is no need to provide guard time intervals between the data blocks that are intended for the various mobile stations. Since the data blocks that are intended for different mobile stations are transmitted in
15   the first data burst from only one transmitter, namely the base station, the guard time intervals for compensation for asynchronous transmission cycles may be omitted. This results in a high data transmission rate.

A further advantage is that, during the transmission of a
20   first data burst, common information (for example, identification information for the piconetwork) may be transmitted only once for two or more data blocks, at the

start of the data burst. This makes it possible to make better use of the available bandwidth.

The invention makes it possible to shorten the transmission time for a frame, and to shorten the latency time. The data
5   transmission system according to the invention is thus particularly suitable for use in systems with real-time requirements.

One frame can be defined for repeated, identically structured transmission sequences between the base station and specific
10   mobile stations. For example, one frame may contain a first data burst, which contains data blocks for specific mobile stations and, subsequently, two or more second data bursts, which are transmitted from specific mobile stations to the base station. The data transmission system according to the
15   invention reduces the transmission time for a frame such as this, thus shortening the latency times.

One preferred refinement of the invention provides for the base station and each mobile station to each have a local oscillator. During transmission operation, the frequency of
20   the local oscillator is used to up-mix the baseband signals to the transmission frequency. During reception operation, received signals are down-mixed by the local oscillator frequency to an intermediate frequency band. Local

oscillators may be in the form of low-cost electronic components.

The local oscillators are advantageously each included in a phase locked loop (PLL). The phase locked loop controls the

5   frequency of the local oscillator at the frequency of a reference oscillator, to be precise sufficiently accurately that the phase difference is maintained. The phase locked loop cannot only receive the frequency, but also can produce a desired frequency. The use of a phase locked loop makes it

10   possible to match the receiver-end oscillator frequency to the transmission frequency.

According to one particularly preferred refinement of the invention, first data bursts and groups of second data bursts are transmitted alternately. In this case, it is possible to

15   provide for a first data burst and a subsequent group of that second data bursts to be transmitted at different frequencies, and/or for a group of second data bursts and a subsequent first data burst to be transmitted at different frequencies. Furthermore, the transmission frequency is preferably kept

20   constant during the transmission of a first data burst and during the transmission of a group of second data bursts. This measure means that the local oscillators need to be stabilized to a new transmission frequency only when changing from the first to second data bursts or from the second to

first data bursts. The stabilization times make it necessary to provide relatively long guard time intervals. Since the transmission frequency is not changed during the transmission of a group of second data bursts, the guard time intervals

5 between successive second data bursts may, in contrast, be relatively short, since no stabilization process has taken place. This correspondingly increases the data transmission rate.

A guard time interval with the same length as that between a

10 second data burst and a subsequent first data burst is preferably provided between a first data burst and a subsequent second data burst. The FCC rules for the ISM frequency bands require a specific number of frequency changes within specific time intervals. The guard time intervals may

15 be used for changing to a new transmission frequency. It is also possible to provide for the guard time intervals to have the same lengths between successive second data bursts. The purpose of these guard time intervals is protection against time overlapping of second data bursts as a result of any

20 asynchronous transmission cycles of the stations, for example as a result of clock drift. These guard time intervals between successive second data bursts are generally shorter than the guard time intervals between first and second data bursts, since there is no need for the stabilization of the

25 oscillators in this case.

One particularly preferred refinement of the invention is characterized in that the transmitters each produce identification information for the piconetwork at the start of the transmission of each first and of each second data burst.

5 An identification such as this identifies the respective receiver at the start of a transmission of a data burst which is intended for the associated piconetwork. According to the invention, the configuration of the data blocks, which are intended for different mobile stations in the single first

10 data burst, means that there is no need to transmit identification information for each data block that is transmitted to a mobile station. This results in a higher data transmission rate.

According to a further advantageous embodiment of the

15 invention, the first data bursts contain two or more data blocks, with one data block being provided for each of the mobile stations. Furthermore, it is advantageous for each of the mobile stations to provide a second data burst in each group of second data bursts. The advantage of this measure is

20 standardization of the transmission sequence. Since each mobile station is addressed in each first data burst and each mobile station is allocated a time slot for transmission of the second data burst in a group of second data bursts, the transmission sequence is clearly structured. The alternative

25 to this would be to check, before transmission of each first

data burst and each group of second data bursts, the mobile

stations to which data blocks are intended to be transmitted,

and which of the mobile stations require a time slot for data

transmission to the base station. Inhomogeneous frame

5   structure such as this would make the latency time worse.

The data transmission system according to the invention can be

used, for example, in short-range cordless communication

systems. This will be advantageous for cordless telephones

with two or more mobile parts. A further application

10   possibility for computer-controlled games systems. In this

case, the mobile stations would be the game pads of the

individual players. Owing to the short latency time, the use

of the data transmission system according to the invention is

particularly advantageous for systems that are subject to

15   real-time requirement. In the case of real-time systems, an

input that is made at the mobile station end must be

transmitted to the fixed station within a defined time

interval, which cannot be exceeded. In a corresponding

manner, a data block that is produced at the base station end

20   must be transmitted to the mobile station in a time interval

that cannot be exceeded. A real-time requirement such as this

occurs in computer-controlled games systems.

The frame structure according to the invention is used for

radio transmission of data bursts between a base station and

at least two mobile stations. The frame structure has first
data bursts, which are transmitted from the base station to
mobile stations. At least some of the first data bursts
contain two or more data blocks that are intended for

5   different mobile stations. Furthermore, the frame structure
has second data bursts, which are transmitted from at least
one of the mobile stations to the base station. The second
data bursts contain data blocks that are intended for the base
station. The frame structure according to the invention has

10 guard time intervals between successive data bursts.

The frame structure according to the invention has the
advantage that there is no need to provide guard time
intervals between the data blocks that are intended for the
mobile stations. Since the data blocks that are intended for

15 different mobile stations are transmitted in the first data
burst by only one transmitter, namely the base station, there
is no need for guard time intervals to compensate for
asynchronous transmission cycles. This shortens not only the
transmission time for a frame, but also the latency time.

20 Other features that are considered as characteristic for the
invention are set forth in the appended claims.

Although the invention is illustrated and described herein as
embodied in a data transmission system, a frame structure, and

a method for radio transmission of data, it is nevertheless

not intended to be limited to the details shown, since various

modifications and structural changes may be made therein

without departing from the spirit of the invention and within

5   the scope and range of equivalents of the claims.

The construction and method of operation of the invention,

however, together with additional objects and advantages

thereof will be best understood from the following description

of specific embodiments when read in connection with the

10   accompanying drawings.

Brief Description of the Drawings:

Fig.1 is a schematic drawing showing the configuration of a

data transmission system according to the prior art and

including one base station and four mobile stations;

15   Fig.2 is a chart showing a frame structure that is used for

prior-art data transmission systems; and

Fig.3 is a chart showing a frame structure according to the

invention.

Description of the Preferred Embodiments:

20   Referring now to the figures of the drawings in detail and

first, particularly to Fig. 1 thereof, there is shown a data

transmission system that includes one base station B and, for
example, four mobile stations Mi (i = 1, …, 4). The base
station B can transmit data by radio to each of the mobile
stations Mi. The mobile stations Mi can likewise transmit

5   data by radio to the base station B. The base station B and
the mobile stations Mi each have a local oscillator LO for
data transmission for a radio. A data transmission system
such as this including one base station and N mobile stations
is referred to as a piconetwork, and has only a short range.

10 Fig.2 shows a frame structure that is used, by way of example,
in the Bluetooth Standard, in order to interchange data
between the base station B ("Master") and the mobile stations
Mi ("Slaves"). Within a frame Ra, data bursts are transmitted
as downlinks from the base station B to each of the mobile

15 stations Mi. After receiving a data burst, each of the mobile
stations Mi transmits a data burst as an uplink to the base
station B, alternating with the downlinks. Each data burst is
allocated its own time slot. One time slot TBMa is available
for the transmission of a data burst from the base station B

20 to a mobile station Mi. A data burst is transmitted from a
mobile station Mi to the base station B during a time slot
TBMa. A guard time interval $\Delta T1$, during which no data is
transmitted, is provided after each transmission of the data
burst.

By way of example, it is possible to provide for the transmission frequency to be varied after each downlink or uplink. Guard time intervals ΔT1 are provided between the transmission of individual data bursts in order to allow the

5   local oscillators LO in the stations to stabilize at the new transmission frequency. If the transmission frequency is not changed between successive data bursts, the guard time intervals ΔT1 are used to compensate for any asynchronous transmission cycles between the stations.

10   The frame structure which is shown in Fig.2 allows the time Tra that is required for transmission of one frame Ra to be calculated using the following equation:

$$Tra = N \cdot (TBMa + TMBa + 2 \cdot \Delta T1) \quad (1)$$

Equation (1) was based on the assumption of the more general

15   situation, in which the data transmission system N has different mobile stations.

Each of the data bursts that are shown in Fig.2 includes different groups of data and information. By way of example, in the Bluetooth Standard, identification information CAC

20   (Channel Access Code) for the piconetwork is transmitted at the start of a data burst, followed by the actual data block that is to be transmitted, the header information H, payload

data D and a checking bit pattern CRC (Cyclic Redundancy

Check) for error identification and correction for the payload

data D.

As an exemplary embodiment of the invention, Fig.3 shows the

5   structure of a frame Rb which is transmitted between the base

station B and the mobile stations Mi in a data transmission

system according to the invention. A data block is in each

case transmitted from the base station B to each of the mobile

stations Mi as the downlink in a first data burst. The data

10   block which is transmitted from the base station B to the

mobile station M1 is annotated "B → M1" in Fig.3. The data

block which is transmitted from B to M2 is annotated in a

corresponding way "B → M2" etc. A time slot TBMb is planned

for the first data bust. The transmission of the first data

15   burst is followed by a guard time interval ΔT2. During the

guard time interval ΔT2, the local oscillators LO are

stabilized at a new transmission frequency. After this,

successive data bursts are transmitted from each of the mobile

stations Mi to the base station B, as uplinks. One time slot

20   TMBb is available for each of these data bursts. The

transmission frequency remains constant during the

transmission of the uplinks. Guard time intervals ΔT3 are

provided between the uplinks in order, for example, to prevent

any time overlap between the uplinks owing to asynchronous

transmission cycles.   The transmission of the uplinks is once again followed by a guard time interval $\Delta T2$.   During this time, the transmission frequency is changed for the transmission of a new frame Rb.

5   During the transmission of a frame Rb, it is necessary to ensure that the FCC regulations are complied with.   This means that the time slots TBMb and TMBb which are provided for the data bursts are sufficiently short to make it possible to change the transmission frequency sufficiently frequently.

10   As in Fig.2, the data blocks in the exemplary embodiment shown in Fig.3 contain header information H, payload data D and a checking bit pattern CRC.   The header information H for the data blocks "B $\rightarrow$ Mi", i = 1, … , 4, represents identification information for the respective mobile stations Mi and, in the

15   Bluetooth Standard by way of example, includes a 3-bit address for the mobile station Mi.   The header information H for the data blocks "Mi $\rightarrow$ B", i = 1, … ,4 is the identification information for the base station B, that is to say its address.   At the start of a data burst, identification

20   information CAC for the piconetwork is transmitted (in the Bluetooth Standard this is called CAC, the so-called Channel Access Code, which is formed by a 72-bit long sequence).

For the general case with N mobile stations involved, the transmission time TRb for a frame Rb according to the invention is driven by the following equation:

$$TRb = TBMb + N \cdot TMBb + 2 \cdot \Delta T2 + (N - 1) \cdot \Delta T3 \quad (2)$$

5   In order to make it possible to compare equation (1) with the equation (2), it is assumed that the time slot TBMb for a first data burst according to the exemplary embodiment illustrated in Fig.3 is the same as the N times time slot TBMa. Furthermore, the time slots TBMa, TMBa and TMBb should

10   have the same lengths T. The guard time intervals $\Delta T1$, $\Delta T2$ and $\Delta T3$ are likewise assumed to be identical with the same length ΔT. In consequence, equation (1) becomes:

$$Tra = 2 \cdot N \cdot T + 2 \cdot N \cdot \Delta T \quad (3)$$

With the approximations mentioned above, equation (2) assumes

15   the following form:

$$TRb = 2 \cdot N \cdot T + (N + 1) \cdot \Delta T \quad (4)$$

According to equations (3) and (4), the transmission time TRb for the exemplary embodiment according to the invention is shorter than the transmission time TRa as shown in Fig.2,

20   provided that the data transmission system has at least two

mobile stations Mi. This shortening results from the saving

of guard time intervals between the data blocks in the first

data burst in Fig.3.

The comparison of equations (3) and (4) has not yet taken into

5   account the fact that the transmission of N-1 identification

information CAC does not take place in the first data burst

according to the invention. This likewise shortens the

transmission time TRb compared to TRa.

In summary, a TDMA and a TDD structure with bidirectional

10 channels between the mobile stations Mi and the base station B

is created, which to this extent is "asymmetric" with separate

unidirectional channels being used for the uplink and a common

channel with dynamic allocation of the data rate being used

for the downlink.